United States Patent [19]

McConnel

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[54] **METHOD AND APPARATUS FOR REFRACTING A LASER BEAM**

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[58] **Field of Search** ..... 350/418, 419, 453, 319; 356/138; 362/257, 259; 219/121 LR; 372/53, 55, 66

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,403,348	9/1968	Ashkin et al. .	
3,435,363	3/1969	Patel .	
3,528,727	9/1970	Halliday	350/413
3,569,660	3/1971	Houldcroft .	
3,604,789	9/1971	McLafferty .	
3,617,928	11/1971	Hausmann .	
3,638,139	1/1972	Ashkin et al. .	
3,654,569	4/1972	Hausmann .	
3,685,882	8/1972	Van Der Jagt .	
3,817,604	6/1974	Watt	350/481
3,873,939	3/1975	Guile et al. .	
3,918,800	11/1975	Griffin .	
3,973,217	8/1976	Guile .	
3,973,218	8/1976	Kepler et al.	350/319
3,976,364	8/1976	Lindemann et al. .	
4,074,208	2/1978	Mack et al. .	
4,090,572	5/1978	Welch .	
4,112,388	9/1978	McLafferty .	
4,121,085	11/1978	Diemer et al. .	
4,138,777	2/1979	Kepler et al. .	
4,178,078	12/1979	Hausmann .	
4,201,952	5/1980	Stewart et al. .	

OTHER PUBLICATIONS

IEEE, May 1967, *Microwave Theory and Techniques* Acoustic Gas Lenses for Light.

Berreman, 1964 The Bell System Tech. Journal 43: 1476–1479, A Gas Lens Using Unlike, Counter Flowing Gases.

Marcuse et al., 1964 The Bell System Tech. Journal 43: 1759–1782, Analysis of a Tubular Gas Lens.

Miska, 1977 Materials Engineering 86(5): 50–52, The Focus is on Lasers for Fabricating Metal Products.

LaBuff, 1980 Report General Electric Co. pp. 1–5, Limit Parametric Study.

Campillo and Shapiro "Toward Control of Self Focusing" *Laser Focus* 10(6): 62–65.

Humphrey et al., *Vortex Devices* Fluidics 1965, pp. 186–188.

McCormack, 1975 *Proceedings of The Royal Irish Academy* Sect. A: 57–72.

Avidor, 1979 AIAA Journal, 17: 1267–1268, Improved Free Vortex, Subsonic, Aero-dynamic Window.

Otis et al., Canadian Journal of Physics 1974, 52: 257–264, Lensing Effect in Helical TEA Lasers.

Beck, 1964 The Bell System Tech. Journal, 43: 1818–1820, Thermal Gas Lens Measurements.

Beck, 1964 The Bell System Tech. Journal, 43: 1821–1825, Gas Mixture Lens Measurements.

Berreman, 1964 The Bell System Tech. Journal, 43: 1469–1475, A Lens or Light Guide Using Convectively Distorted Thermal Gradients in Gases.

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[57] **ABSTRACT**

This invention is a method and apparatus for refracting a laser beam. The beam can be collimated, focused, or expanded by passing it along the longitudinal axis of a volume of gas which has a radial pressure gradient. The pressure gradient causes a corresponding gradient in density and refractive index. Such a gradient can conveniently be established by the use of a gas vortex chamber. A vortex chamber will act as a negative lens. It can be located at or near the focal point of a focused laser beam as a collimating element. A gas vortex lens is useable at power densities above those which conventional optical materials can withstand.

17 Claims, 15 Drawing Figures